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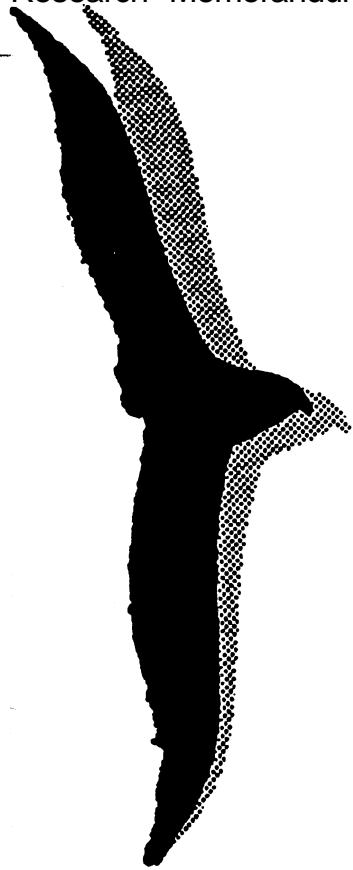
## Serie research memoranda

Modelling labour market dynamics with on-the-job search

F.A.G. den Butter  
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by F.A.G. den Butter and C. Gorter\*

## Summary

A flow model of the Dutch labour market is used to calculate the effects of policy options which aim to enhance employment, especially at the lower end of the labour market. The model distinguishes between good and bad jobs, allows for endogenous wage formation and job creation, and describes the flows between these jobs so that job-to-job mobility and the vacancy chain is made endogenous. In the matching process employed job seekers with bad jobs compete with short-term and long-term unemployed for the filling of vacancies for good jobs. In each period part of the good and bad jobs are destroyed which results in inflow into unemployment. The model explicitly describes the flow of unemployed through the various duration classes of unemployment and it allows for negative duration dependence so that the escape probability from unemployment for long-term unemployed is smaller than for short-term unemployed. The model is used to simulate the effects of external shocks, such as structural productivity shocks. An impulse response analysis using the model is also conducted considering labour market policies which aims especially to enhance employment at the lower end of the labour market. In particular, the effects are analyzed of measures subsidising the opening of bad jobs (jobs at the lower end of the labour market) and a rise in the productivity of a bad job as compared to a good job which can be achieved by changes in the tax system.

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## 1. Introduction

On-the-job search and the resulting job-to-job mobility is an important aspect of labour market dynamics, both from the theoretical and from the policy perspective. Most theoretical (and also empirical) models of dynamic search theory focus on transitions from unemployment or non-participation to employment, and vice versa, but disregard transitions within the state of employment. However, Pissarides (1994) has extended the traditional search model to a case **where on-the-job** search becomes an economic choice variable. He shows that the results of the traditional search model are enriched but that introduction of on-the-job search does not change anything fundamental in that model of search equilibrium.

From the policy perspective job-to-job mobility is important as it is a major determinant of the effectiveness of measures which aim at enhancing employment, especially at the lower end of the labour market. When workers leave an old job for a better one, the old job may not be destroyed but become vacant and that vacancy can be taken by an unemployed worker. Only a model with endogenous on-the-job search can indicate how the vacancy chain (or musical chair) mechanism will be affected by policy measures.

In this paper we present a compact and consistently calibrated model of labour market flows at the macro level for the Netherlands, which endogenizes the job-to-job flows. Hereto the model distinguishes between good jobs and bad jobs where workers with bad jobs compete in the matching process for good jobs with short-term and long-term unemployed. The model focuses on a number of empirical facts from labour market dynamics and search behaviour, namely (i) that net employment changes are very small compared to gross flows of job creation and job destruction, (ii) that labour turnover, which includes all movements of personnel is much larger than job turnover which is the sum of job creation and job destruction, and (iii) that the exit probability from unemployment to employment is duration dependent, i.e. that long term unemployed have a smaller exit probability than short term unemployed. The baseline simulation of the model describes a dynamic flow equilibrium and is calibrated to the actual size of labour market flows in the Netherlands, and to parameter estimates for the matching process. The model explicitly describes the flows of unemployed through the various duration classes of unemployment, so that the model fully reproduces the propagation dynamics of shocks (including policy measures) which affect unemployment.

Search theory can only explain on-the-job search, and hence job-to-job mobility, in the case of heterogeneous jobs. Evidently in the case of homogeneous jobs all jobs are the same and there is no reason for looking for another job when one is already employed. Obviously in reality almost all jobs are different, but such heterogeneity cannot be built into a flow model of the labour market at the macro level. Therefore, the distinction in our model between bad jobs and good jobs is only a very stylized representation of job heterogeneity in the real world. In our model, workers holding a good job have again no reason to search for another job. The meaning of a bad job in our model is therefore rather fuzzy and should be considered in relation to the quality and preferences of the worker holding the job. In this representation a good job can turn into a bad job because of a change in technology, but also because of a change in the taste and preferences of the worker, e.g. because he or she has obtained additional education.

Our model tries, in a way, to transform the theoretical equilibrium search model of Pissarides (1994) with on-the-job search to an empirical model for policy analysis. Similar to the search model with on-the-job search of Pissarides, good jobs are assumed to be different from bad jobs in our empirical flow model because of their higher productivity and more expansive “set-up” costs. As our empirical flow model describes the matching process in

connection with the dynamic propagation process of shocks through the duration classes of unemployment, no analytical solution of the model is possible. Therefore we need a numerical solution and an impulse analysis in order to investigate the working of the model. The major aim of the simulation experiments of this paper is to see how the dynamic propagation of shocks and the effects of measures of labour market policy are affected by the interaction between the mechanism of job to job mobility and the processes of search, job destruction, job creation and wage formation.

The contents of the rest of the paper is as follows. The next section discusses the model. Section 3 gives a description of the dynamic equilibrium simulation of two alternative baselines. These baseline simulations differ with respect to the assumption on duration dependency. Section 4 discusses the effects of a number of policy measures by means of dynamic impulse-response simulations. Finally section 5 gives some conclusions.

## 2. The model

The model describes the various flows between the following stocks at the macro level:

U : Unemployment  
N : Non-participants or outside the labour force (residual stock)  
V : Vacancies  
E : Employment

Total employment is supposed to consist of two parts, namely bad jobs (Eb) and good jobs (Eg):

$$E = E_b + E_g \quad (1)$$

Consequently vacancies may relate either to bad or to good jobs (Vb and Vg)

$$V = V_b + V_g \quad (2)$$

Our model describes both the flows of persons, which are symbolised as  $F_{xy}$  for a flow from stock x to stock y, and inflows and outflows of vacancies, symbolised by  $V_{bI}$ ,  $V_{gI}$  and  $V_{bO}$ ,  $V_{gO}$ . For example,  $F_{nu}$  and  $F_{un}$  represent the inflow of non-participants into unemployment and the outflow of unemployed to non-participation respectively. These flows are both exogenous in our model and a labour supply shock can be implemented through the former variable.

### *matching process*

A central feature of our model is the description of the matching process which is also an important mechanism in the theoretical models of search theory. In the present version of our model the inflow of unemployed into employment through the filling of vacancies:

$$F_{uev} = F_{uegv} + F_{uebv} \quad (3)$$

is, in combination with movers from a bad to a good job who fill a vacancy ( $F_{ebegv}$ : upward mobility stream), described by a system of matching functions, specified as a Cobb-Douglas functions (which is in line with various empirical findings on the functional form of the matching function, see e.g., Blanchard and Diamond, 1989, and Van Ours, 1991)

$$F_{uebv} = c_{mb} v b^{1-\alpha_b} (U_s + \theta U_L)^{\alpha_b} \quad (4)$$

$$F_{egv} = c_{mg} V g^{1-\alpha_g} (U_s + \theta U_L + S)^{\alpha_g} \quad (5)$$

$$\text{with } F_{uegv} = \{ (U_s + \theta U_L) / (U_s + \theta U_L + S) \} F_{egv}$$

$$\text{and } F_{ebegv} = F_{egv} - F_{uegv}$$

Here  $\alpha_b$  and  $\alpha_g$  are the weights given to the composite (un)employment variables in the matching process, and with  $c_{mb}$  and  $c_{mg}$  constant terms representing the efficiency of the matching process.  $S$  represents the number of employed job seekers with a bad job. In the following we will discuss how  $S$  is endogenised in the model.

Now

$$\pi_s = uo / (U_s + \theta U_L)$$

$$\pi_L = \theta \pi_s$$

are the escape probabilities from short term and long term unemployment respectively, with  $UO$  the outflow from unemployment. It should be emphasized that in our model the above escape probabilities, and consequently unemployment duration, vacancy duration and employment duration, are endogenously determined since they are derived from the sizes of the endogenous flows and stocks. At the macro level described by our model, the propagation of shocks leads to long-lasting changes in the sizes of these flows and stocks, and result in considerable changes in the escape probabilities and duration variables. We note that most micro studies, which focus on individual characteristics as determinants of escape probabilities and of duration variables, do not reckon with these propagation dynamics of cyclical and structural shocks at the macro level.

The parameter  $\theta$  represents the duration dependence of the escape probability from unemployment. In case  $\theta$  is equal to unity we have no duration dependence and all unemployed obtain the same weight in the matching function. A  $\theta$  between 1 and 0 assumes that the probability of unemployed finding a job reduces when unemployment duration increases. The idea behind this is that long term unemployed, either loose skills or become discouraged and therefore search less actively, see also Pissarides (1990). However, simulations on the working of the ranking theory of Blanchard and Diamond (1994) in the model would require that we distinguish at least between two types of unemployed, namely those who have a priori a high escape probability from unemployment and those who have a low **a priori** escape probability from unemployment. In that case the value of the parameter  $\theta$  in the above formula for the escape probability from long-term unemployment would be **endogenous** and would depend on the position of the cycle: after a downswing of the cycle a lot of workers with high individual escape probabilities have become unemployed, whereas in that period the stock of long-term unemployed will contain a majority of unemployed with low individual escape probabilities. In that case the value of the parameter  $\theta$  will be lower than after an upswing when also most short-term unemployed have low individual escape probabilities.

In the present version of the model the flows of non-participants who find either a bad or a good job by filling a vacancy:

$$F_{nev} = F_{negv} + F_{nebv} \quad (6)$$

we assume that

$$F_{nebv} = (Vb/V) F_{nev} \text{ and } F_{negv} = (Vg/V) F_{nev}$$

In a later version these job matches of non-participants can be endogenised following the empirical results of Broersma and Den Butter (1996) on competition between employed job searchers, unemployed job searchers and non-participants in the matching process.

*job to jobflows*

A crucial assumption in the above system of matching functions is that the motivation of employed job searchers is to move from a bad to a good job. Essentially one can distinguish two sources of the upward mobility flow, namely

- (i) workers improve their productivity (over time)
- (ii) jobs deteriorate in their performance (over time)

As regards the first cause of upward mobility (workers' productivity goes up), it has been shown by Pissarides (1994) that this can be modelled in a theoretical search framework by assuming that wages differ between jobs (e.g. good and bad) and that they increase with tenure. In this framework, a worker that has accepted a bad job will search for good jobs until a wage has increased so much that the marginal costs of search are higher than the marginal benefits of accepting a good job (with a wage at the entrance level). Given certain assumptions in the search theoretical model, Pissarides derives the optimal level of employment search which is determined by the number of workers in bad jobs with a tenure less than a threshold tenure level  $\tau^*$ , the period of holding a bad job after which a worker stops searching for a good job (see for more details, Pissarides, 1994). In our empirical model, we simply assume the level of employed job seekers to be a fraction  $\phi$  of all workers holding a bad job (and thereby avoiding non-stationarities in the model).

Moreover we identify a second source of employed job search by allowing the performance of jobs to change over time. The basic idea is that due to an idiosyncratic shock the good job's productivity may fall and in fact becomes a bad job (see also Millard, 1996). Consequently, the worker perceives to be overqualified and starts looking for a new good job. So we obtain

$$F_{egb} = \Psi(y) E_g \quad (7)$$

In first instance  $\Psi$  is assumed to be fixed in our model, so that the flow from good to bad jobs is a fraction of the number of good jobs. So, we arrive in our model at the following relationship for the total number of employed job seekers:

$$S = \phi E_b + (1-\phi) F_{egb} \quad (8)$$

Here we assume that only a fraction  $\phi$  of the employed in bad jobs are seeking for a good job, but that all of those whose good job turned into a bad job become job seekers in that (particular) period.

### duration classes of unemployment

In order to avoid flows which are larger than the corresponding stocks we specified our model of labour market flows on a monthly basis. The flows of unemployed through the duration classes are modelled as follows:

$$U_{1,t} = UI; U_{k,t} = (1-\pi_s) U_{k-1,t-1} \text{ for } k = 2, 3, \dots, 12.$$

$$U_s = U_1 + U_2 + \dots + U_{11} + U_{12},$$

$$U_L = U - U_s$$

$$(\text{and } U_{L,t} = (1-\pi_L) U_{L,t-1} + (1-\pi_s) U_{12,t-1})$$

Therefore, this part of the model explicitly describes the flow of unemployed through the various duration classes. All inflow into unemployment is assumed to enter in the first duration class. It implies that we do not allow for heterogeneity amongst entrants into unemployment and therefore do not reckon with divergent labour market histories of newly unemployed.

### job destruction

In our model job destruction is, in principle, equal to outflow from employment minus the number of jobs which become a vacancy again when someone flows out of that job. Here

$$F_{eu} = F_{ebu} + F_{egu} = (Eb/E).F_{eu} + (Eg/E).F_{eu} \quad (9)$$

gives the flows of people with bad jobs and good jobs respectively who become unemployed. Although one expects that all of these jobs are destroyed since it is not allowed under Dutch law to hire and fire simultaneously for the same job, it has nevertheless been demonstrated by Hamersmesh, Hassink and Van Ours (1996) that firms are hiring and firing at the same time (in particular, they present an outcome for the probability of jointly hiring and firing for the same jobs of about 0.5). Consequently, we assume

$$VI_{eu} = 0.5. F_{eu} \quad (10)$$

In first instance, we assume that this relationship holds for both good and bad jobs, so

$$\begin{aligned} VbI_{eu} &= 0.5. F_{ebu} \\ VgI_{eu} &= 0.5. F_{egu} \end{aligned}$$

An assumption has also to be made for the autonomous outflow of (unfilled) vacancies, which is (not a very relevant) part of the job destruction process:

$$v o_x = VbO_x + VgO_x = (Vb/V).VO_x + (Vg/V).VO_x \quad (11)$$

and next, assume

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<sup>1</sup> As the model is based on discrete time -intervals, this identity only approximately holds in the simulation experiments.



$$VO_x = 0.1.V$$

### *filled vacancies*

The next equations of the model are definition equations which say that the outflow of vacancies ( $VO_u = VbO_u + VgO_u$ ) associated with the successful matches described 'by the matching function is equal to the flow to employment of those who find a job by filling a vacancy:

$$VbO_u = F_{uebv} \quad (12)$$

$$VgO_u = F_{uegv} \quad (13)$$

Similarly it holds that

$$VO_n = VbO_n + VgO_n = F_{nebv} + F_{negv} = F_{nev} \quad (14)$$

$$\text{and } VgO_e = F_{ebegv} \quad (15)$$

A major assumption with respect to the process of job destruction (job replacement) is on the percentage of good and bad jobs left by workers leaving the labour force (retirement, death, marriage, emigration etc.) that become vacant. For these replacement jobs, we assume the probability that the job will be filled again to be 0.25: obviously more empirical evidence on this aspect is needed to come to a more realistic calibration of our model.

$$VI_{en} = VbI_{en} + VgI_{en} = 0.25 F_{ebn} + 0.25 F_{egn} \quad (16)$$

$$\text{and } F_{en} = F_{ebn} + F_{egn} = Eb/E.F_{en} + Eg/E.F_{en} \quad (17)$$

is exogenous and part of the job destruction process.

However, the workers at bad jobs who move to a good job will, for a major part, leave a vacancy behind. Here we assume that a fraction  $P_c$  of these jobs becomes vacant, and hence, that  $1-P_c$  of these jobs is destroyed:

$$VbI_e = P_c \cdot F_{ebegv} \quad (18)$$

So, the fraction  $P_c$  is one of the parameters of the model which will be referred to as continuation probability (in line with previous research into the effects of vacancy chain, see Gorter et al., 1993 and Gorter and Schettkat, 1994). In the simulation experiments of our model, this continuation probability will be set to a certain - fixed - value.

### *wage formation and job creation*

Wage formation and job creation (that is, the opening of new - good and bad - vacancies) is modelled in a similar framework as developed by Pissarides (1994). The basic idea of Pissarides' model of search equilibrium (with two types of jobs) is to allow for search externalities which affect the level of jobs (i.e., when search intensity of the employed becomes higher due to a positive productivity shock, relatively more marginal good jobs become profitable because employers' search costs for good jobs are relatively lower). The

implication of this change of job composition is - according to Pissarides - that unemployed job seekers have more difficulties to enter the job market. In the dual labour market model of Pissarides, the flows from unemployment to employment are as depicted in Figure 1 shown below.

**Figure 1      Job-to-job transitions in a dual labour market (Pissarides-model)**



The flow-model described before in this paper departs from this framework in some important respects. On the one hand, we simplify Pissarides’ model with respect to the determination of the number of employed job seekers (which is also obtained by solving the relevant optimality condition in his model). We assume here that the number of employed job seekers (S) to be determined by a (fixed) fraction of workers in bad jobs plus the workers in good jobs for whom the job is transferred from a good one into a bad one. On the other hand, we have to adjust the Pissarides-model since our flow-model does not **only** includes “upward” job-to-job moves (as in Pissarides) but also “downward” job-to-job transitions (that is, good jobs may turn into bad jobs). In addition, our model can allow for more flexible matching processes than in Pissarides’ because short-term and long-term unemployed job seekers do not necessarily have equal probability of being hired for good or bad jobs (as can be seen from equation (5)). This inequality in search effectiveness between short-term and long-term unemployed persons can be taken into account in the derivation of the vacancy-wage relationships by adjusting unemployment (U) to the number of effective unemployed job seekers (equal to  $U_s + \theta U_L$ )<sup>2</sup>. In case  $\theta = 1$ , we have a model for homogeneous workers and heterogeneous jobs in which both upward and downward job-to-job flows exist (this type of model could be regarded as a logical extension of the on-the-job search model of Pissarides).

It is now useful to introduce some notation before moving to the specification of the firm’s and worker’s returns from a job. We define the following variables:

- $p_g$         = rate at which a job seeker finds a good job ( $=F_{egv}/U + S$ )
- $p_b$         = rate at which a job seeker finds a bad job ( $=F_{uebv}/U$ )
- $p_{gb}$        = rate at which good jobs become bad jobs ( $=F_{egcb}/E_g = \Psi$ )

<sup>2</sup> However, the behavioural relationship for the asset value of being unemployed will be specified stationarily, so that implicitly it is assumed that unemployed workers do not anticipate the possibility of becoming completely ineffective in the long run. A behavioural model for vacancy creation and wage determination that allows explicitly for **non-stationari-**ties would be extremely difficult to handle analytically, and this approach has therefore not been pursued in this paper (see for example, Van den Berg, 1990 in which a non-stationary relationship for unemployed job seekers has been thoroughly examined in isolation of other behavioural equations).

whereas  $U$  is equal to  $U_s + \theta U_L$ ; and

- $q_g$  = rate at which a firm with a good vacancy finds a worker ( $=F_{egv}/Vg$ )
- $q_b$  = rate at which a firm with a bad vacancy finds a worker ( $=F_{ubv}/Vb$ )
- $k_{g,b}$  = costs of holding/opening a good (g) or bad (b) job
- $Y$  = output
- $w$  = wage
- $s$  = separation rate
- $r$  = discount rate

Next, we present expressions for the asset values to each of the worker and job states in our model in order to be able to endogenize the wage rates for good and bad jobs, and the vacancy supply (see also Gautier and Den Butter, 1995 in which jobs are assumed to be homogeneous). First, we consider the firm's behaviour in the dual labour market. For good jobs, we obtain the following asset values. In case of an unfilled good job, the expected profit from opening a good job vacancy is denoted by  $V_g$ , and then it holds that

$$rV_g = -k_g + q_g(J_g - V_g) \tag{19}$$

whereas  $J_g$  is defined as the expected profit of recruiting a worker for a good job, and  $r$  is the discount rate. So, equation (19) shows that the asset value of an unfilled job ( $r.V_g$ ) is equal to the probability that a (good) vacancy is filled ( $q_g$ ) times the associated change in value when it is filled ( $J_g - V_g$ ) minus the costs of having an open position ( $k_g$ ).

If the job is filled,  $J_g$ , the expected profit, satisfies

$$rJ_g = y - w_g - k_g - (s + p_{gb}).(J_g - V_g) \tag{20}$$

In words, the asset value of a filled job is equal to the productivity in a good job (net of wage costs and operation costs) minus the change in wealth when the job is left by the current employee or when the job's nature becomes bad (that occurs with the sum of the probabilities  $s$  and  $p_{gb}$ ).

In equilibrium, the rents of openings new jobs are assumed to be fully exploited which makes the expected profit of a good job ( $V_g$ ) equal to zero. Consequently, we have that  $q_g.J_g$  is equal to  $k_g$  in equilibrium.

Similar expressions for the asset values can be written down for bad jobs (in which the productivity is a fraction  $a$  of the productivity of a good job,  $y$ ). Let  $V_b$  be the expected profit from opening a bad job vacancy, and  $J_b$  be the expected profit from recruiting a worker for a bad job, then we get for the asset values of a vacant bad job ( $r.V_b$ )

$$rV_b = -k_b + q_b(J_b - V_b) \tag{21}$$

and for an occupied bad job ( $r.J_b$ )

$$rJ_b = ay - w_b - k_b - (s + p_g) \cdot (J_b - V_b) \quad (22)$$

In equation (22), the associated loss in wealth ( $J_b - V_b$ ) occurs when the job becomes vacant which happens either when a job separation takes place (with probability  $s$ ) or when an upward job-to-job move takes place (with probability  $p_g$ ). Again, when equilibrium is characterized by total rents exhaustion (that is, expected profit  $V_b$  equal to 0) then we get  $q_b \cdot J_b$  equal to  $k_b$ .

Let us now turn to be the behaviour of workers and present the asset values of (i) being unemployed and (ii) being employed in either a good or bad job. The asset value of being unemployed is given by

$$rU_{js} = p_g(E_g - U_{js}) + p_b(E_b - U_{js}) \quad (23)$$

in which  $U_{js}$  is defined as the expected returns from job search during unemployment. Equation (23) shows that the asset value of being unemployed depends on the wealth gains of becoming employed in a good job, multiplied with the probability to get that job plus the net surplus from having a bad job, multiplied with the probability to obtain such a job.

As regards to the asset value of having a good job ( $rE_g$ ), we have

$$rE_g = w_g - s(E_g - U_{js}) - p_{gb}(E_g - E_b) \quad (24)$$

with  $E_g$  defined as the expected returns from accepting a good job. Equation (24) shows that the asset value is equal to the wage (in a good job) minus the wealth loss when becoming unemployed (times the probability that a separation occurs), and also minus the wealth loss when the job is being transformed from good into bad (times the associated probability). In case of having a bad job, the expected returns from accepting such a job,  $E_b$ , satisfies

$$rE_b = w_b - c + p_g(E_g - E_b) - s(E_b - U_{js}) \quad (25)$$

when the employee is searching (if not equation (25) will resemble equation (24)).

So, for those who are searching, the asset value of having a bad job is equal to the wage (net of search costs), plus the wealth gain of moving to a good job (multiplied with the probability of achieving this promotion), minus the wealth loss that occurs in case of a separation (i.e., becoming unemployed).

It is assumed that wages split the surplus of a match between the worker and the firm. So we get for good jobs

$$E_g - U_{js} = \beta[(J_g - V_g) + (E_g - U_{js})] \quad (26)$$

and for bad jobs, this becomes

$$E_b - U_{js} = \beta[(J_b - V_b) + (E_b - U_{js})] \quad (27)$$

where the parameter  $\beta$  is defined as the worker's share of the match surplus (and which indicates the union's power in the Nash - bargaining process).

Using now the no-profit conditions ( $V_g = V_b = 0$ ), together with (20), (24), (26) and also (27) for the final step, we obtain for  $w$ ,:

$$w_g = rU_{js} + \beta[y - k_g - rU_{js} - p_{gb}J_g] + (1-\beta)p_{gb}(E_g - E_b) = rU_{js} + \beta[y - k_g - rU_{js} - p_{gb}J_b] \quad (28)$$

and when using (22), (25) and (27), we get for  $w$ ,:

$$w_b = rU_{js} + \beta[\alpha y - k_b - rU_{js}] - (1-\beta)[p_g(E_g - U_{js}) - c] \quad (29)$$

These wage equations can be compared with expressions that would occur when there were no job-to-job mobility flows (for bad jobs in that case, the wage is equal to the first two terms on the RHS in (29) and for good jobs a similar relationship holds with  $\alpha = 1$ ). Pissarides has already shown that the wage reduction in a bad job (due to on-the-job search) is equal to the firm's share of the surplus that the worker creates by searching on the job. In our extended version of the Pissarides-model, there is also a wage reduction in good jobs ( $(1-\beta) \cdot p_{gb} \cdot (E_b - U_{js}) = \beta \cdot p_{gb} \cdot J_b$ ) that is actually the net result of the firm's share of a wage compensation demanded by workers ( $(1-\beta) \cdot p_{gb} \cdot (E_g - E_b)$ ) minus the worker's share of the loss for the firm ( $\beta \cdot p_{gb} \cdot J_g = (1-\beta) \cdot p_{gb} \cdot (E_g - U_{js})$ )

In equilibrium, the following conditions hold:

- (i) Inflow of unemployment is equal to outflow from unemployment:  
 $s(1-u) = (p_g + p_b)u$ , with  $u$ , the unemployment rate, equal to  $U/(U+E)$
- (ii) Rents of good jobs are exhausted:  
 $q_g \cdot J_g = k_g$
- (iii) Rents of bad jobs are exhausted:  
 $q_b \cdot J_b = k_b$

The model can now be solved for the stock of vacancies  $V$  (good and bad:  $V_g, V_b$ ) and the associated wages ( $w_g$  and  $w_b$ ) by making use of the conditions for vacancy entry (ii) and (iii)<sup>3</sup>. An important additional assumption is made to derive the vacancy stocks and associated wage levels, namely that profits from job entry are unaffected by search. This implies that the wage compensation offered by the searching employees in bad jobs is equal to the loss of the firm: so in equation (29) we have  $[(1-\beta) \cdot p_g \cdot (E_g - U_{js}) - c]$  equal to  $[p_g \cdot J_b = p_g/q_b \cdot k_b]$ . A similar approach is followed in Pissarides' model when he derives the so-called

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<sup>3</sup> Note that condition (i) describes the Beveridge (or vacancy-unemployment) curve.

vacancy curve in case employed job seekers exist (see for more details, Pissarides, p. 466, p. 469 and p. 474).

The equations for the vacancy variables then become as follows (based on (20) and (22), respectively):

$$Vg = \frac{(y - k_g - w_g)}{r + s + p_{gb}} \cdot \frac{F_{egv}}{k_g} \quad (30)$$

and

$$Vb = \frac{(ay - k_b - w_b)}{r + s + p_g} \cdot \frac{F_{uebv}}{k_b} \quad (31)$$

whereas we find for the wage variables:

$$w_g = rU_{js} + \beta \cdot [y - k_g - rU_{js} - p_{gb} \cdot k_b \cdot \frac{V_b}{F_{uebv}}] \quad (32)$$

and

$$w_b = rU_{js} + \beta \cdot [ay - k_b - rU_{js}] - \frac{\frac{F_{egv}}{U + S}}{\frac{F_{uebv}}{V_b}} \cdot k_b \quad (33)$$

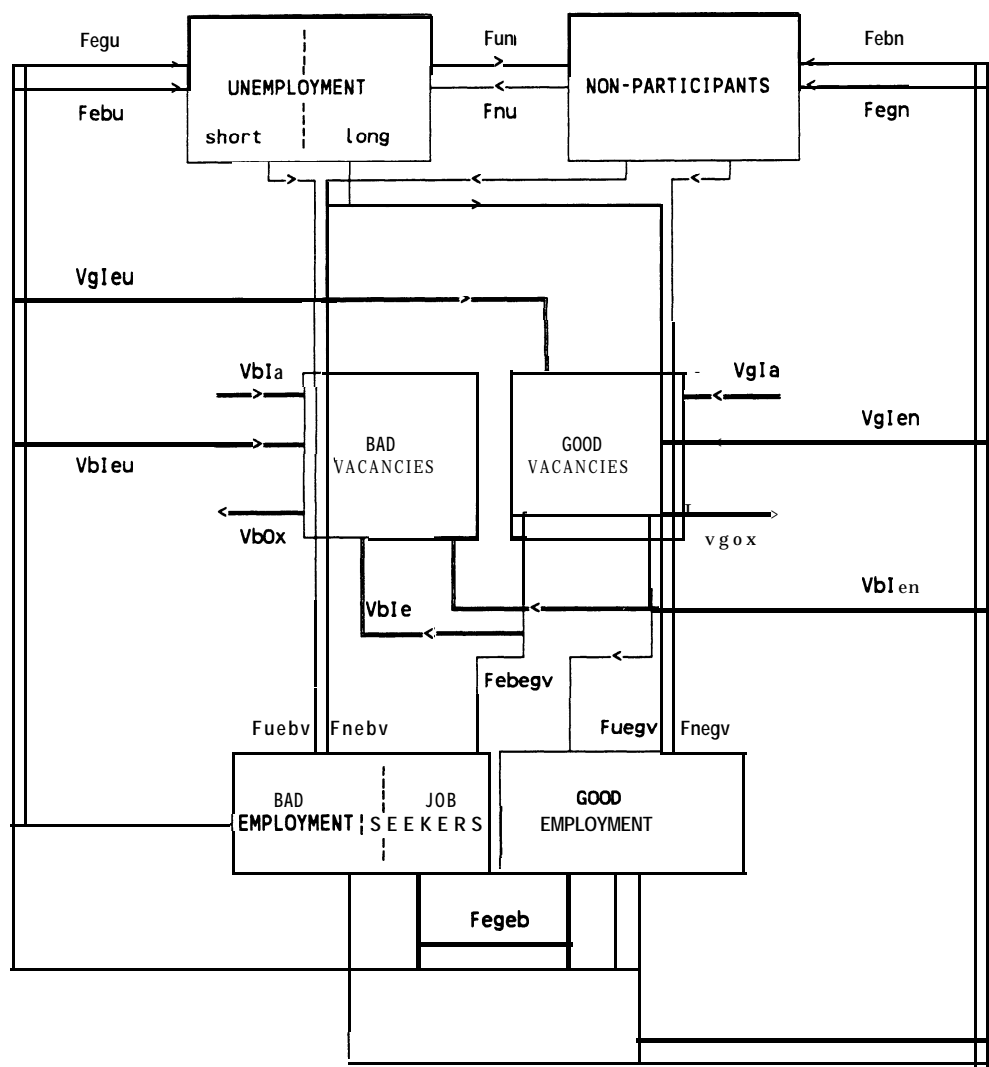
with  $rU_{js}$  (the asset value of unemployment) equal to

$$rU_{js} = \frac{\beta}{1 - \beta} \cdot [\frac{p_g}{q_g} k_g + \frac{p_b}{q_b} k_b] = \frac{\beta}{1 - \beta} \cdot [\frac{V_g}{U + S} k_g + \frac{V_b}{U + S} k_b] \quad (34)$$

which can be derived when using the sharing rules and the equilibrium conditions

To close the model we have the equations of motion which set the stocks of the model equal to the respective stocks in the previous period plus the inflows ( $VbI$ ,  $VgI$ ,  $UI$ ,  $EbI$ ,  $EgI$ ) minus the outflows ( $VbO$ ,  $VgO$ ,  $UO$ ,  $EbO$ ,  $EgO$ ). In Appendix I, we show the complete set of stock-flows relations for the number of vacancies, the number of unemployed and the number of employed. This concludes the description of our flow model with heterogenous (good and bad) jobs. The structure of this model in terms of stocks and flows is **comprehensively** demonstrated in Figure 2.

Figure 2 Stocks and Flows in the Dual Labor Market



legend :

- [ ——— ] : worker flows
- [ === ] : job flows

### 3. Calibration and baseline simulation

Our investigation of the model is started by calculating a central projection of the simulation experiments. The central projection (or baseline simulation) is computed as a dynamic equilibrium of our model, based on average monthly values for the exogenous flow variables and also conditional on the equilibrium values of the (endogenous) stock-variables (see for similar analyses, Gautier and Den Butter, 1995, Den Butter and Van Dijk, 1997).

The basic projection assumes 400,000 unemployed, and a total level of employment of 6 million, which mimics the present situation in the Netherlands. According to this projection the share of long-term unemployed in total unemployment amounts to about 40%. This is in accordance with the actual percentage in the early 1990's, which may indicate that the labour market situation in that period can be described adequately by the dynamic equilibrium and the escape probabilities from unemployment of the basic projection of our model. It should be noted that in the baseline simulation of our model all stocks and flows are constant. It implies that the calibration of the baseline simulations is bounded by the fact that the inflow into each stock should be equal to its outflow. The data on the exogenous flows in the data set had to be (slightly) corrected in order to comply with this condition. This correction also enables us to make assumptions on the specific value of total unemployment and employment in the baseline simulations. Although these stocks are constant in the baseline simulations, they are endogenous in the model and will deviate from their equilibrium values in impulse simulations where the economy is hit by a shock which brings it temporarily out of equilibrium. The flow equilibrium of the baseline simulations for the variables which are determined by the matching function is achieved by setting appropriate values to the constant terms of the matching functions. Yet we need a numerical solution for fixing these constant terms (representing the efficiency of the matching process) because of the non-linearities introduced by the different weights given to the various unemployment classes in the matching function, and because of the fact that in equilibrium the inflow into each duration class of unemployment should be equal to the outflow from that class. The model is solved using numerical procedures from the GAUSS-programme.

We emphasize that our calibration does not purport to yield a central projection which gives a good dynamic description of the historical time path of the endogenous variables of the flow model. The sole aim of our baseline simulation is to mimic a dynamic flow equilibrium as a reference scenario, which comes close to the actual situation.

So, initially fixed values are selected for the level of unemployment (U) and employment (E). In addition, we also select for the baseline simulation constant levels for the (exogenous) flows from (un)-employment to non-participation and vice versa ( $F_{un}$ ,  $F_{en}$ ,  $F_{nn}$ ,  $F_{ee}$ ) and for the flow from employment to unemployment ( $F_{eu}$ )<sup>4</sup>. We do not need to set the values for the stock of (good and bad) vacancies, since these are endogenously determined in

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<sup>4</sup> Note also that  $F_{un}$  is set equal to  $F_{nn}$ , and  $F_{en}$  equals  $F_{ee}$  (in equilibrium).



the model (and  $w_g$  and  $w_b$  are also resolved, according to the relations shown in the previous section. see equation (33) and (34)). It is also noteworthy to mention that the distribution of employment over good and bad jobs is endogenously determined in our model also (and hence, the same applies to the number of employed job seekers,  $S$ ).

In our “baseline”-version of the model, we do not estimate the matching-parameters on vacancies, unemployment and employed job seekers, but choose fixed values in line with previous empirical work for the Netherlands ( $\alpha_b$  and  $\alpha_g$  are both set equal to OS), see e.g. Van Ours, 1991, Gorter and Van Ours, 1994.

The second group of parameters that have to be set in our model is related to the flows from and to the stock of good jobs. The flow from good to bad is assumed to be a fraction of the stock (and this value  $\Psi$  is set at 0.075); the flow from bad to good jobs is determined by the proportion of job seekers (see also eq. (8)), here we take  $\phi = 0.001$ . Finally, the continuation probability related to jobs left by employees moving upward has to be chosen, and we start with  $P_c$  equal to 1 (so all of these jobs become vacant again).

To calibrate the model we finally need to select values for the parameters on (i) costs of holding a good/bad job ( $k_g/k_b$ ,  $k_g > k_b$ ), (ii) worker’s/firm’s share of the match-surplus ( $\beta/1-\beta$ ,  $0 < \beta < 1$ ), (iii) the discount rate ( $r$ ), (iv) the separation rate ( $s$ ) and (v) real value of the production per good/bad worker ( $y/a_y$ ,  $0 < a < 1$ )<sup>5</sup>. The configuration of parameters is chosen in the baseline such that we have an about equal number of good and bad jobs. Moreover, the number of vacancies is calibrated at the level of about 100 which is consistent with the labour market situation in the Netherlands at the beginning of the 90’s. The distribution of vacancies over good and bad is also about equal.

In table 1, we present the numerical values of a set of (endogenous) variables of particular interest for our baseline models<sup>6</sup>. In baseline I, we have the case of “homogeneous workers-heterogeneous jobs” ( $\theta = 1$ ), whereas in baseline II, unemployed and employed job seekers are not different, but part of the long-term unemployed have become ineffectiveness job seekers ( $\theta = 0.5$ ). In the following discussion, the focus is on the wage ratio, the transition rates and the length of the vacancy chain. In baseline II, a wage rate in good jobs is

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<sup>5</sup> In our central projection, we have taken the following configuration of parameter values:  $k_g = 0.8$ ;  $k_b = 0.3$ ;  $\beta = 0.5$ ;  $r = 0.01$ ;  $s = 0.01$ ,  $y = 1$  ( $a = 0.5$ ). Empirical evidence on the structural parameter-values is extremely scarce in the literature (see for a notable exception, Yashiv, 1997).

<sup>6</sup> When we actually solved the model numerically, a striking result was detected. It appeared that the model has more than one solution, in other words we face a situation of multiple equilibria in our dual labour market. In particular, the composition of bad and good employment in the baseline simulation is rather sensitive to the choice of the starting values (of the endogenous variables in the model), the other endogenous variables are however quite stable.

observed that is 50% higher than the wage in a bad job (whereas productivity is twice as high in a good job, but the cost of opening a good job is more than twice as high). In baseline I (with homogeneous labour), the wage ratio is equal to 1.7. Another difference between baseline I and II is shown in the magnitudes of the transition rates. Clearly the escape rate from unemployment is the same for short- and long-term unemployed in baseline I, and at a level (0.09) that is lower than that of short-term unemployed in baseline II (0.11) and higher than that of long-term unemployed in baseline II (0.05). In the bad labour segment, transition rates for both workers and employers (jobs) are substantially smaller in the homogeneous labour case (baseline I). Finally, we look at the outcome for the average length of the vacancy chain which is computed as the total number of replacement jobs over the total number of newly created jobs. One new job in the labour market leads on average to about 3/4 additional (replacement) job in both baseline simulations.

[ Table 1 about here ]

#### 4. Impulse response analysis

In this section, we present simulation exercises of our model in which we show the labour market dynamics due to changes in parameters and exogenous variables. They represent measures of labour market policy which aim at enhancing employment. All simulations are conducted with both alternative dynamic equilibria as baseline (where in baseline I  $\theta = 1$  and in baseline II  $\theta = 0.5$ ), so that differences in impulse responses indicate the sensitivity of the effects of the policy measures for the degree of duration dependency of the exit probability from unemployment<sup>7</sup>. The dynamic simulations are based on myopic foresight of the agents. This implies that employers create new jobs in each period according to the “vacancy equation” (see [30] and [31]), given the disequilibrium values for stocks and flows in this period<sup>8</sup>.

We present the results of the simulation exercises described above in Tables 2, 3 and 4.

The tables show the effects on the set of endogenous variables used in Table 1 (with the exception of the percentage of newly created jobs separately for good and bad jobs)

[ Tables 2,3 and 4 about here ]

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<sup>7</sup> Moreover, we also investigated the robustness of our results to different levels for the endogenous variables in the initial equilibrium (while holding parameters values and exogenous variables constant). It appears that the estimated effects do hardly vary across different initial equilibria (i. e., multiple equilibria), given the same set of values for the parameters and exogenous variables.

<sup>8</sup> An alternative approach could be to assume that the agents have perfect foresight and hence “jump” to the new equilibrium values for the inflow of new jobs immediately. This exercise is left for future research on this topic.

Table 2 gives the effects of an overall increase in productivity. This simulation may represent the consequence of a general policy directed at the enhancement of technical progress and human capital, e.g. by increased investments in R&D and/or schooling. To a large extent, the outcomes of this exercise reflect the developments as sketched by Pissarides (1994) in his theoretical contribution on ‘On-The-Job search’. An overall rise in productivity makes it more attractive for the employer to create good jobs since the absolute costs remain unchanged and hence the net gain of opening a good job is higher than that of opening a bad job. This process is clearly noticed in the increase in good job creation, whereas bad job creation declines (and we also note that the relative wage-differential goes up). Consequently, a considerable shift from bad to good jobs arises: in this case of a policy directed at a general increase in productivity ‘good jobs drive out bad jobs’. A prediction of the theoretical Pissarides’ model that does not show up in our model is that this shift would be harmful for the unemployed. On the contrary, we observe a reduction of unemployment in our dynamic simulation. The reason why this does not correspond with the implication of the Pissarides’ model lies in the different modelling of the number of employed job seekers. In our case, it is a fraction of the number of persons holding a bad job (and therefore it goes down), whereas in Pissarides’ model the number of employed job seekers is determined in a structural sense (as has been discussed in section 2) which gives rise to an increase in this number when the opportunities improve to enter the good job segment. The outcomes of this exercise do not appear to be much sensitive to the degree of duration dependency. It is remarkable that the increase in productivity brings about an increase in the wage differential between good and bad jobs. From that perspective it seems that the increase in productivity leads to a rise in income inequality. The results for the average length of the vacancy chain show that there are no big changes in the amount of bad jobs which become vacancies due to job-to-job mobility.

Table 3 presents the results of a policy measure which aims especially to enhance employment at the lower end of the labour market, namely a reduction in the costs of opening a bad job. This can be achieved, for instance, by employment subsidies for low productivity jobs. Table 4 gives the results of an alternative policy simulation, namely an increase in the production per worker in a bad job. It is tempting to consider it as the result of additional schooling of low productivity workers but we should mind that the model allows for job heterogeneity but not for worker heterogeneity. Therefore, this exercise may also represent a policy of reducing employers’ taxes at the lower end of the labour market.

Essentially, the two types of labour market policies of tables 3 and 4 work out similarly (as can be understand when we reconsider the relationship for job creation as shown in [30] and [3 1]). There is a clear and substantial shift from good to bad employment in both cases whereas the net gain in employment is also about the same for both labour market policies. The driving factor for this outcome is the change in job creation, that is the major rise in bad job creation and the less strong reduction in good job creation. This process goes together -as could be expected - with declining wage-differentials between the segments. This tendency towards income equality is somewhat larger in the simulation with an increase

in productivity than in case of a reduction of the costs of opening a bad job. The vacancy chain effect becomes much less in the short-run due to the fall-back in good job opportunities. Later on this reduction becomes gradually smaller as a result of the major enlargement of the number of persons holding a bad job, and hence also the group of people seeking a good job. The sensitivity analysis shows that the effects of these policy measures on employment are much larger in the case that long term unemployed have a smaller exit probability than short term unemployed as compared with the situation of no duration dependency'. All in all the simulations show that when policy measures are specifically directed at the lower end of the labour market 'bad jobs drive out good jobs'<sup>10</sup>.

### Conclusions

In this paper, a flow model of a dual labour market is developed that includes job to job movements and vacancy chains. In the matching process, the model allows for differences in search effectiveness between short-term and long-term unemployed job seekers. Moreover, optimal behaviour of the agents with respect to job creation and wage formation is taken into account in this model with heterogenous jobs by using a search equilibrium approach. The model can be regarded as an empirical extension of Pissarides' (1994) theoretical dynamic unemployment equilibrium model with on-the-job search.

An exploration of the dynamic equilibrium path of the model for the Dutch labour market by means of simulation experiments shows that the level and • even more strongly • the composition of employment is influenced by incremental changes in structural parameters of our model, which represent labour market policies. In particular, a higher overall level of productivity leads to a major shift from bad to good jobs, whereas labour market policies that make the creation of bad jobs more attractive clearly show an opposite development. The results indicate that with general policy measures good jobs drive out bad jobs, whereas with policies especially directed at the lower end of the labour market bad jobs drive out good jobs. The simulation exercises also show that the propagation of the policy measures takes quite a long time and that the transition to a new equilibrium is not achieved in the short run. This result may, however, be influenced by our assumption of 'myopic rational' behaviour where wages and vacancy supply is set as if all actual flows are equilibrium values. A scope for further research is a sensitivity analysis of the recognition lags with respect to this assumption. Moreover, in a following version of the model we may also allow for worker heterogeneity in addition to job heterogeneity (e.g., to take into account differences in the relative efficiency of employed job seekers in the matching process as

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<sup>9</sup> Note also that the rate of leaving unemployment for the short-term unemployed in case of negative duration dependence is higher than the hazard rate for the unemployed when duration dependence is absent (see Table 1).

<sup>10</sup> It does not mean, however, that overqualified drive out qualified: such finding would require a model which distinguishes different kind of workers, and not (only) different kind of jobs.

compared to unemployed job seekers. which would also have consequences for the structural behaviour of the agents with respect to job creation and wage formation). The final aim is to develop a model which gives, in the framework of search theory, a detailed description of opportunities to climb job ladders (and to fall off), and acquire human capital. However, in that case we face the risk to end up with a large model with many equations which is against the present trend in modelling.

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**Table 1**                      **Characteristics of equilibrium path of a baseline simulation**  
**for a (selected) set of endogenous variables**

	<u>baseline I</u> ( $\theta = 1$ )	<u>baseline II</u> ( $\theta = 0.5$ )
unemployment (x 1000) <sup>1</sup>	400	400
short-term unemployed	267	240
long-term unemployed	133	160
employment (x 1000)	6000	6000
employment in bad jobs	2632	3000
employment in good jobs	3368	3000
vacancies (x 1000)	<b>93</b>	87
vacancies for bad jobs	43	45
vacancies for good jobs	50	42
ratio $w_g/w_b$	17	15
transitions rates		
rate of finding a good job ( $p_g$ )	0.03	0.03
rate of finding a bad job ( $p_b$ )	0.03	0.05
rate of findind a good worker ( $p_g$ )	0.36	0.37
rate of finding a bad worker ( $p_b$ )	0.31	0.35
rate of leaving unemployment (STU)	0.09	0.11
rate of leaving unemployment (LTU)	0.09	0.05
Average length of vacancy chain	1.72	1.75

<sup>11</sup> Note that our model allows for different values for the level of total employment (unemployment). As said before, we initially choose the level of employment (unemployment) to be equal to 6000 (400).

**Table 2**            **Effects of an increase in productivity (y), y: +4 %**

	baseline I, after			baseline II, after		
	1 yr	3 yrs	10 yrs	1 yr	3 yrs	10 yrs
<u>Effects on</u>						
unemployment (x 1000)	-11.3	-18.9	-21.0	-8.3	-15.8	-19.9
employment (x 1000)	11.3	18.9	21.0	-38.8	-108.0	-158.1
employment in bad jobs	-34.7	-99.1	-244.1			
employment in good jobs	45.9	118.0	265.2	46.9	123.8	283.9
vacancies (x 1000)	12.6	10.4	8.7	12.2	10.7	8.9
vacancies for bad jobs	-5.7	-6.4	-6.6	-5.2	-5.7	-6.0
vacancies for good jobs	18.3	16.8	15.3	17.4	16.4	14.9
ratio $w_g/w_b$ (x100)	2.9	2.9	2.9	3.6	3.6	3.6
average length of vacancy chain (x100)	-0.9	0.0	-0.6	-0.1	0.4	-0.1



**Table 3**            **Effects of a reduction in the costs of opening a bad job ( $k_b$ ),  $k_b$ : -5%**

	baseline I, after			baseline II, after		
	1 yr	3 yrs	10 yrs	1 yr	3 yrs	10 yrs
<u>Effects on</u>						
unemployment (x 1000)	-20.0	-33.1	-36.4	-23.0	-42.7	-52.3
employment (x 1000)	20.0	33.1	36.4	23.0	42.7	52.3
employment in bad jobs	57.7	141.5	308.3	63.0	154.5	328.8
employment in good jobs	-37.7	-108.5	-271.9	-40.0	-111.9	-276.5
vacancies (x 1000)	12.8	10.1	10.2	11.3	8.8	8.2
vacancies for bad jobs	22.2	19.9	19.4	21.0	18.7	17.5
vacancies for good jobs	-9.3	-9.8	-9.2	-9.6	-9.8	-9.4
ratio $w_g/w_b$ (x100)	-11.1	-11.1	-11.1	-13.0	-12.9	-12.7
average length of vacancy chain (x 100)	-6.1	-3.5	-2.0	-7.6	-4.7	-2.5

**Table 4**      **Effects of an increase in the production per bad worker (a),  $\alpha$ : +5 %**

	baseline I, after			baseline II, after		
	1 yr	3 yrs	10 yrs	1 yr	3 yrs	10 yrs
<u>Effects on</u>						
unemployment (x 1000)	-21.1	-34.8	-38.3	-24.3	45.0	55.0
employment (x 1000)	21.1	34.8	38.3	24.3	45.0	55.0
employment in bad jobs	68.0	168.4	370.9	74.9	185.7	401.5
employment in good jobs	-46.9	-133.6	-332.6	-50.6	-140.7	-346.5
vacancies (x 1000)	13.9	11.0	11.1	11.9	9.2	8.5
vacancies for bad jobs	25.8	23.3	22.7	24.4	21.8	20.6
vacancies for good jobs	-12.0	-12.4	-11.6	-12.5	-12.6	-12.1
ratio $w_g/w_b$ (x100)	-14.6	-14.6	-14.6	-17.1	-16.9	-16.7
average length of vacancy chain (x 100)	-6.9	-4.1	-2.5	-8.6	-5.5	-3.1

**Appendix I: Equations of Motion**

Vacancies:

For bad vacancies, we have

$$Vb = Vb_{.1} + VbI - VbO$$

with  $VbI = VbI_{cu} + VbI_{cn} + VbI_e + VbI_a$

and  $VbO = VbO_n + VbO_u + VbO_x;$

For good vacancies, we have

$$Vg = Vg_{.1} + VgI - vgo$$

with  $VgI = VgI_{cu} + VgI_{cn} + VgI_a$

and  $VgO = VgO_n + vgo, + VgO_e + vgo,;$

These equations endogenize the autonomous vacancy inflow VI, ( $VbI_a$  and  $VgI_a$ ) as V ( $Vb$  and  $Vg$ ) are determined by equations (26) and (27):

$$VI = V - V_{.1} + VbO + VgO - VbI_{cu} - VbI_{cn} - VbI_e - VbI_a - VgI_{cu} - VgI_{cn} - VgI_a$$

with  $VbO + VgO =$

$$VbO_n + VbO_u + VgO_n + VgO_u + VgO_e + VbO_x + VgO_x =$$

$$F_{nebv} + F_{ucbv} + F_{negv} + F_{uegv} + F_{ebegv} + VO_x$$

Unemployment:

$$U = U_{.1} + UI \cdot uo$$

with  $UI = F_{cu} + F_{nu}$

and  $UO = F_{uev} + F_{un} = F_{ucbv} + F_{uegv} + F_{un};$

Employment :

$$E_b = E_{b,1} + E_{bI} - E_{bO}$$

with  $E_{bI} = F_{u\ e\ b\ v} + F_{ncbv} + F_{egb}$

and  $E_{bO} = F_{ebu} + F_{ebn} + F_{cbegv}$ ;

$$E_g = E_{g,1} + E_{gI} - E_{gO}$$

with  $E_{gI} = F_{ucgv} + F_{negv} + F_{cbegv}$

and  $E_{gO} = F_{cgu} + F_{cgn} + F_{cgeb}$ ;